

# The Global Geodetic Observing System

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Koganei, Tokyo, Japan

# International Association of Geodesy

- The mission of the IAG is to advance geodesy
- This mission is performed by its components
  - Commissions and Inter-commission Committees
  - Services
  - Global Geodetic Observing System (GGOS)
- IAG Commissions & Inter-commission Committees
  - Represent the major fields of geodetic research within the IAG
  - Represent the IAG in all relevant scientific matters
    - Commission 1: Reference Frames
    - Commission 2: Gravity Field
    - Commission 3: Earth Rotation and Geodynamics
    - Commission 4: Positioning and Applications

# IAG Services

- Organize the collection and reduction of geodetic observations
  - Create the geodetic products needed for scientific research and societal applications
- Geometry
  - IERS, IGS, IVS, ILRS, IDS
- Gravimetry
  - IGFS, BGI, ISG, IGETS, ICGEM, IDEMS
- Oceanography
  - PSMSL
- Standards
  - BIPM

# Global Geodetic Observing System

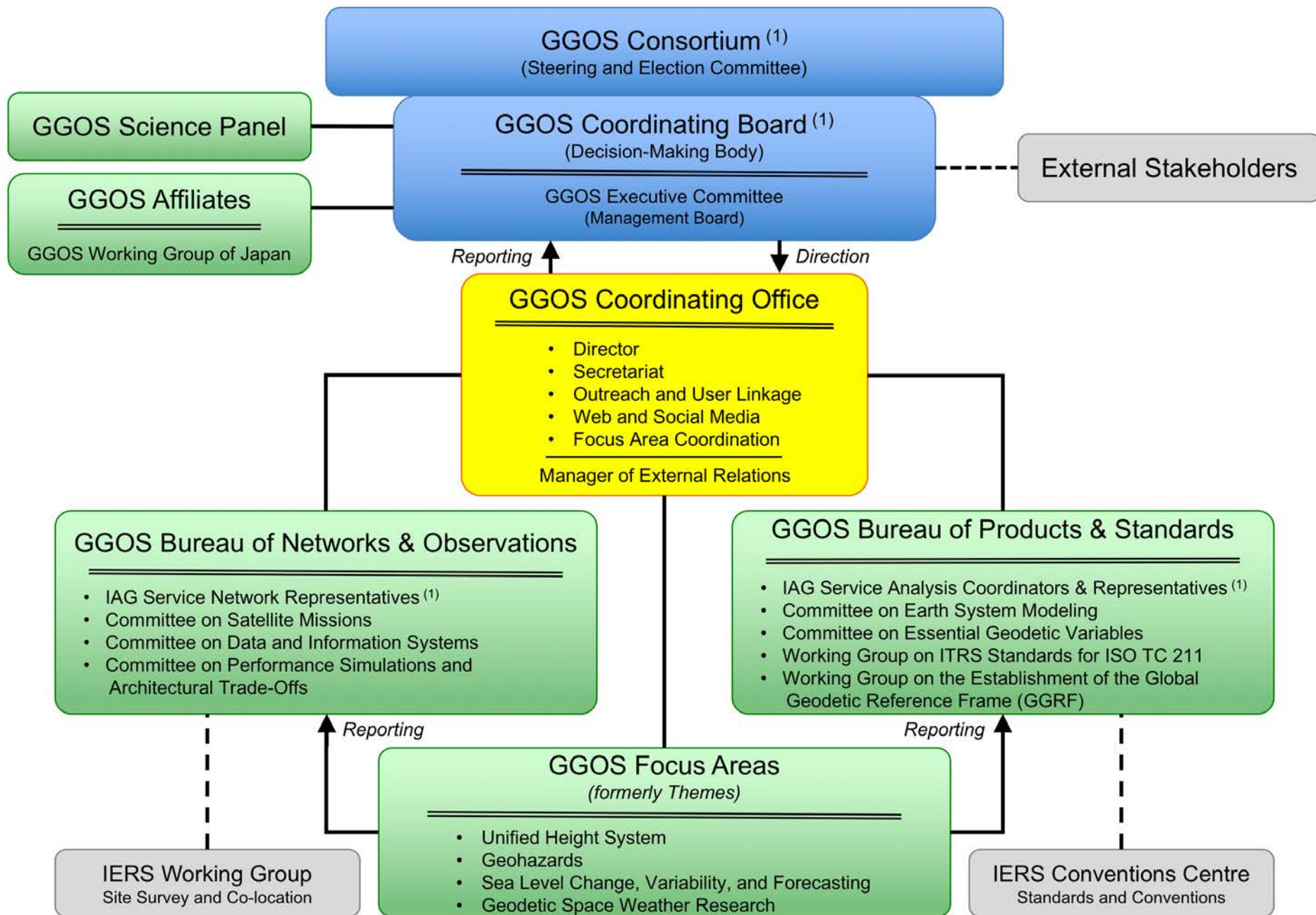
- Established by IAG
  - 2003 as IAG Project; 2007 as full component of IAG
- *The observing system of the IAG*
  - Organize the technique-specific Services under one unifying umbrella
  - Form a comprehensive geodetic observing instrument
  - Integrate the hitherto separate pillars of geodesy (shape, rotation, and gravity) into one consistent observing system
- Provide the geodetic expertise and infrastructure needed to monitor the Earth system and to conduct global change research
  - IAG Commissions and Services are the backbone of GGOS
- Represents IAG in GEO & contributes to GEOSS

# GGOS Mission

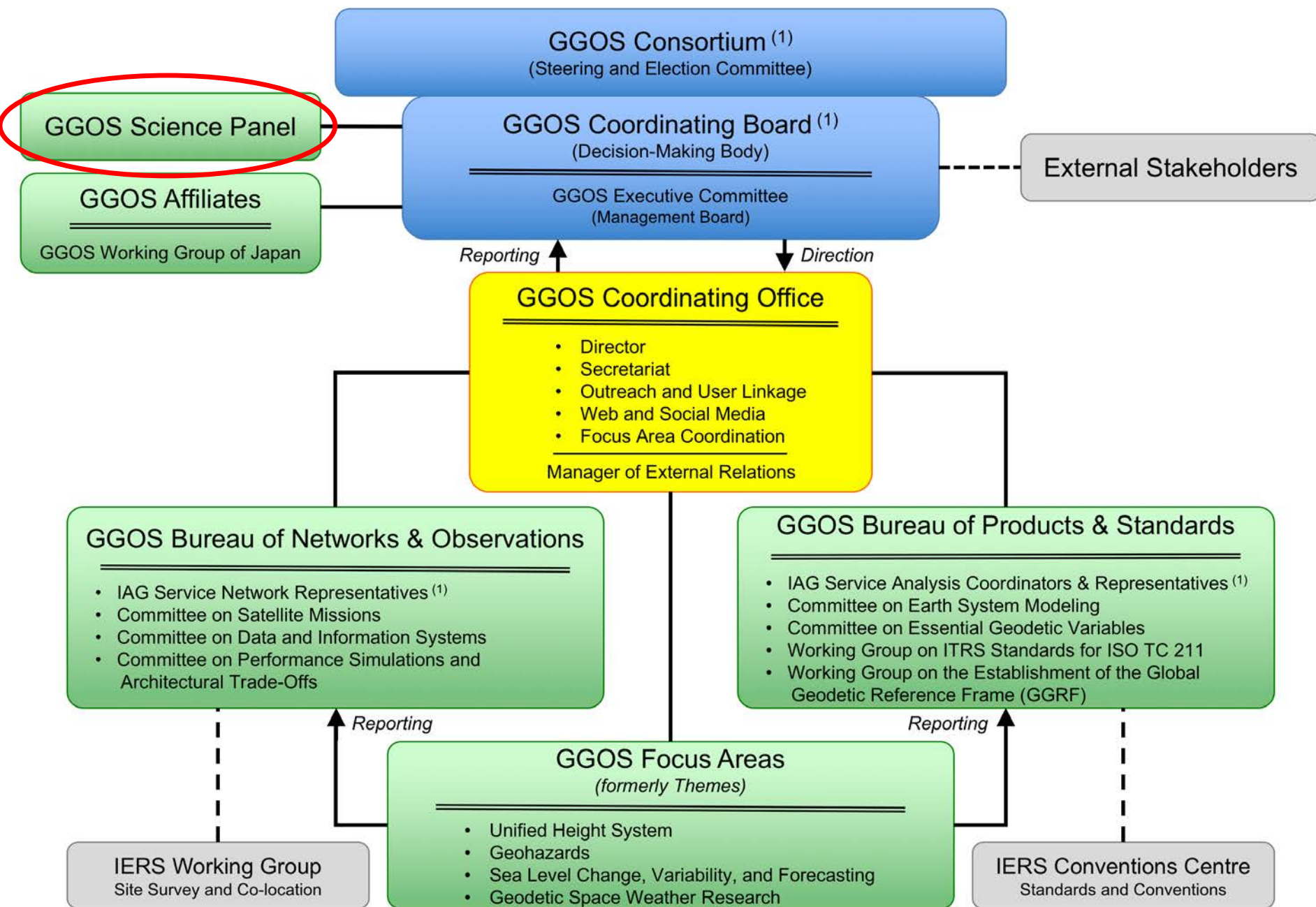
We live on a dynamic planet in constant motion that requires long-term, continuous quantification of its changes in a truly stable frame of reference.

The mission of GGOS is:

- *to provide the observations needed to monitor, map and understand changes in the Earth's shape, rotation and mass distribution;*
- *to provide the global geodetic frame of reference that is the fundamental backbone for measuring and consistently interpreting key global change processes and for many other scientific and societal applications;*
- *to benefit science and society by providing the foundation upon which advances in Earth and planetary system science and applications are built.*



<sup>(1)</sup> GGOS is built upon the foundation provided by the IAG Services, Commissions, and Inter-Commission Committees



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# Science Panel

- Role

- Independent, multi-disciplinary advisory board

- Provides scientific support & guidance to GGOS steering & coordination entities
- Represents geodetic and geoscience communities at GGOS meetings

- Activities

- Supports all other GGOS entities upon request

- Contributes to GGOS publications

- Reference document, journal articles

- Organizes & participates in GGOS Science workshops

- Geodesy, Astronomy, and Geophysics in Earth Rotation, Wuhan, July 2016

- Co-Organizes (with IERS) Unified Analysis Workshops

- Paris, France; July 2017

- Organizes & participates in GGOS sessions at conferences

- EGU, AGU, IAG, IUGG, AOGS, JpGU

- Participates in GGOS meetings

- Consortium, Coordinating Board, Executive Committee



# Science Panel Members

## IAG Commission 1

Geoff Blewitt (USA)

Markus Rothacher (Switzerland)

## IAG Commission 2

Thomas Gruber (Germany)

Kosuke Heki, Chair (Japan)

## IAG Commission 3

Jianli Chen (USA)

José Ferrándiz (Spain)

## IAG Commission 4

Pawel Wielgosz (Poland)

Jens Wickert (Germany)

## IAG ICC Theory

Mattia Crespi (Italy)

Yoshiyuki Tanaka (Japan)

## GGOS Focus Area 1

(Unified Height System)

Bernhard Heck (Germany)

## GGOS Focus Area 2

(Geohazards)

Diego Melgar (USA)

## GGOS Focus Area 3

(Sea Level Change)

Don Chambers (USA)

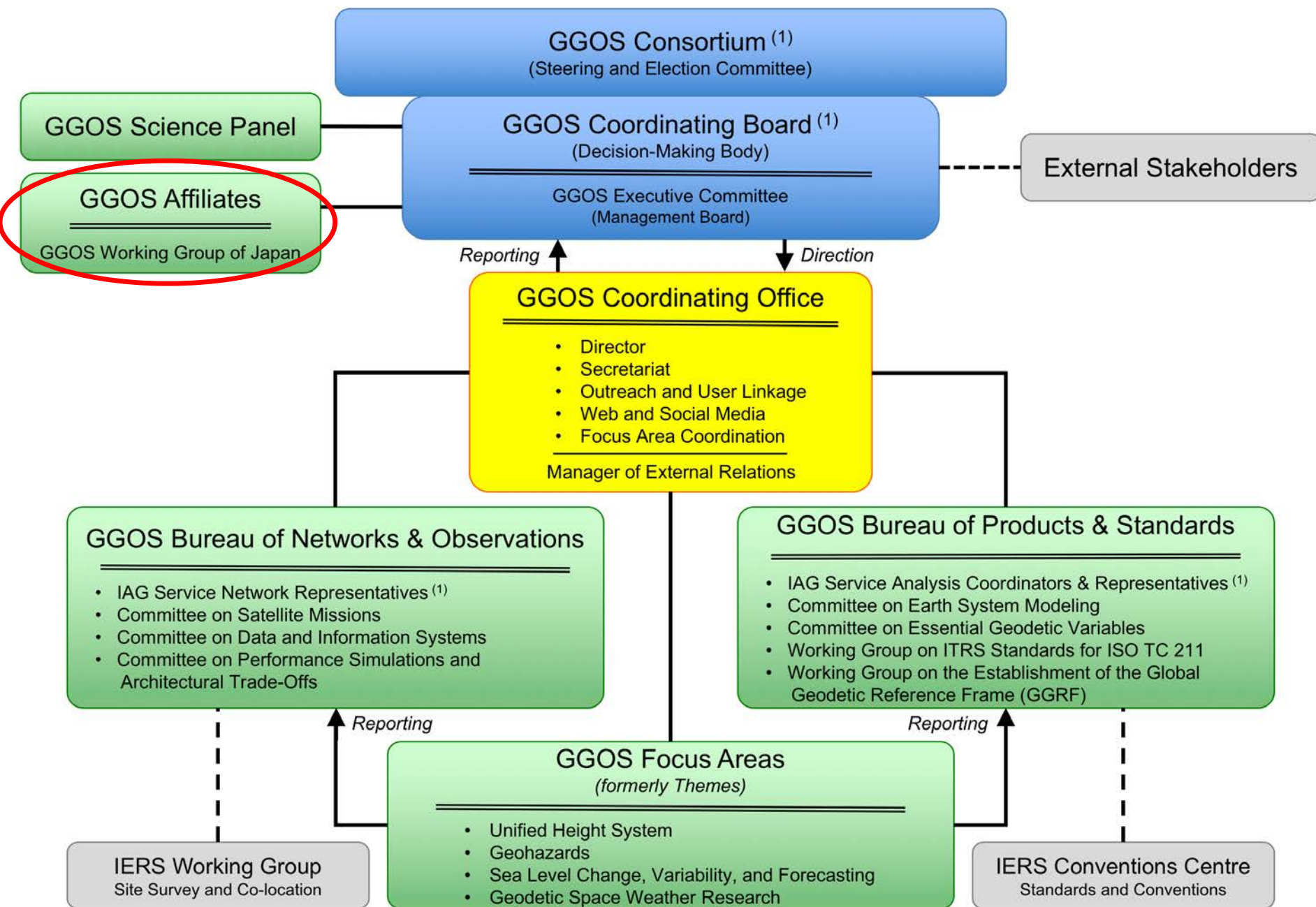
## GGOS Focus Area 4

(Space Weather Research)

Ehsan Forootan (UK)

## Immediate Past Chair

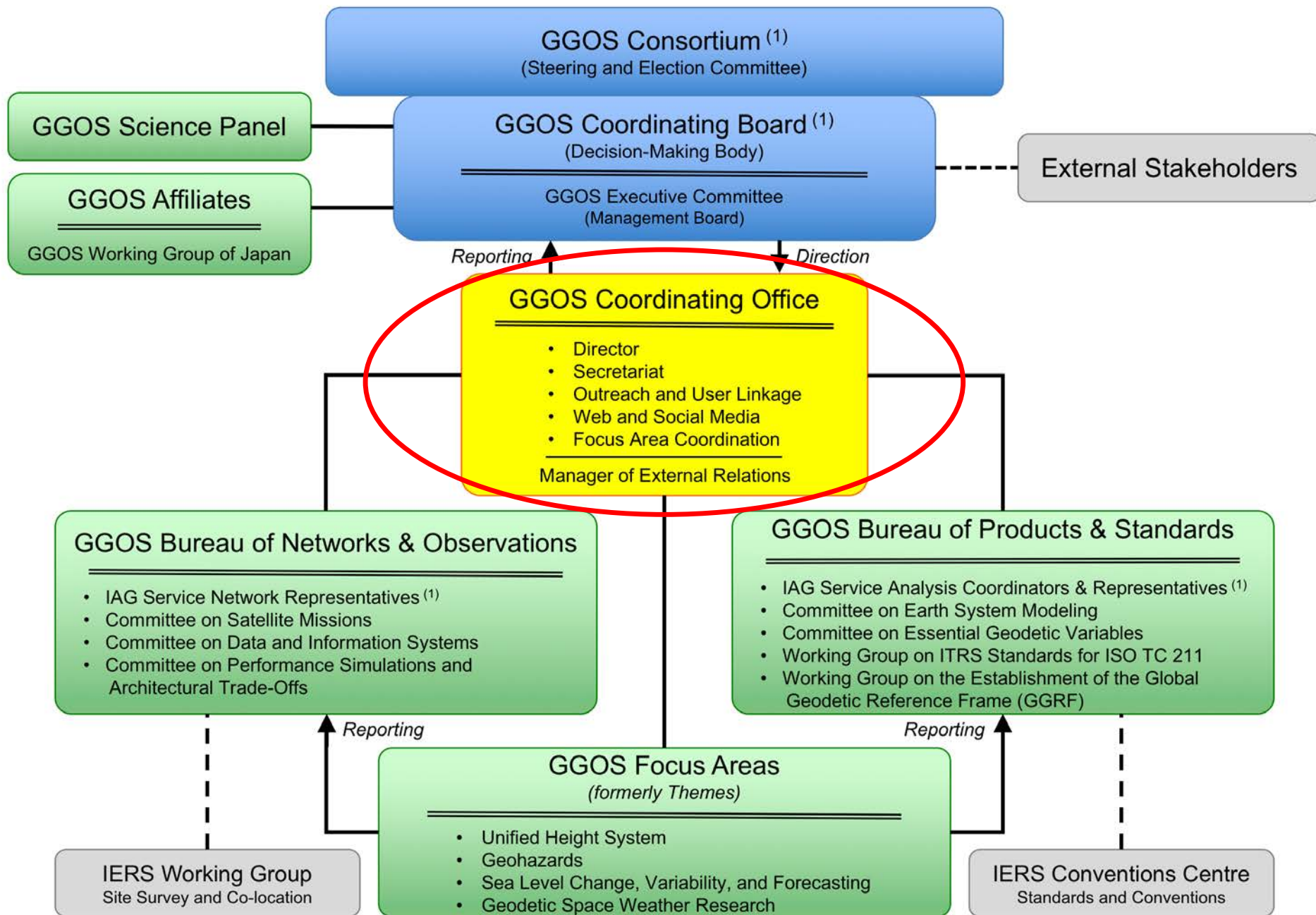
Richard Gross (USA)



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# GGOS Affiliate

- National or regional organization
  - That coordinates space-geodetic activities there
- Established to increase participation in GGOS
  - Particularly from under-represented areas
    - Africa, Asia, South and Central America
- Is a component of GGOS
  - With representation on Consortium and Coordinating Board
    - Each GGOS Affiliate has 1 representative to Consortium
    - Collectively they have 2 representatives to Coordinating Board
- First GGOS Affiliate
  - GGOS Working Group of Japan
    - Established in 2013; Chair: Toshi Otsubo of Hitotsubashi University, Japan
    - Provides forum for multi-technique, space-geodetic discussions within Japan
    - Strives to improve quality of observations & encourage collaboration in Japan
- Encourage others to become GGOS Affiliates
  - Particularly important for nations/regions where multiple agencies own space-geodetic equipment



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# Manager of External Relations

- Expanding involvement in external organizations
  - Group on Earth Observations (GEO)
    - GGOS Chair appointed to GEO Programme Board for 2018-2020
  - Committee on Earth Observation Satellites (CEOS)
    - Limited participation at present
    - Should be expanded to complement GGOS participation in GEO
  - UN-GGIM Subcommittee on Geodesy
    - Will establish an appropriate governance mechanism for sustaining GGRF
- Requires better approach to managing activities
  - Past approach rather *ad hoc* in nature
    - Volunteer-based
    - Little long-term stability in representation
- Position of Manager of External Relations created
  - To coordinate GGOS engagement with external organizations
    - Resides within GGOS Coordinating Office
    - Appointed by GGOS Chair subject to approval by GGOS Coordinating Board
    - Member of Coordinating Board and Executive Committee
- Allison Craddock selected as first Manager



# GGOS External Relations

GGOS External Relations Near-Term Goals  
*Connecting GGOS with the United Nations*



There is tremendous potential to increase the exposure and impact of GGOS by identifying potential contributions and connecting existing relevant work to efforts in support of both UN SDGs and the Sendai Framework.

GGOS has the potential to facilitate linkages to agencies and other providers of geodetic data, make existing geodetic data discoverable and easily accessible, and to work toward standardization.

## Group on Earth Observations (GEO)



- GGOS represents the IAG in the Group on Earth Observations as a contributor to the GEO Foundational Task **GEOSS In-Situ Earth Observation Resources**;
- IAG/GGOS has been selected to be a member of the **GEO Programme Board during 2018-2020**, with Gross being the Principal Representative and Craddock acting as alternate.
- External Relations also connects the GGOS CO to the GEO Communicators Network.

## UN GGIM Subcommittee on Geodesy



United Nations

- GGOS supports and, as needed, represents the IAG at the United Nations Committee of Experts on Global Geospatial Information Management (UN GGIM).
- GGOS Consortium members H. Schuh and D. Angermann participate in Subcommittee Focus Groups on behalf of the IAG, with Consortium members Gross, Craddock, and G. Johnston participating on behalf of their nations.

## Committee on Earth Observation Satellites (CEOS)

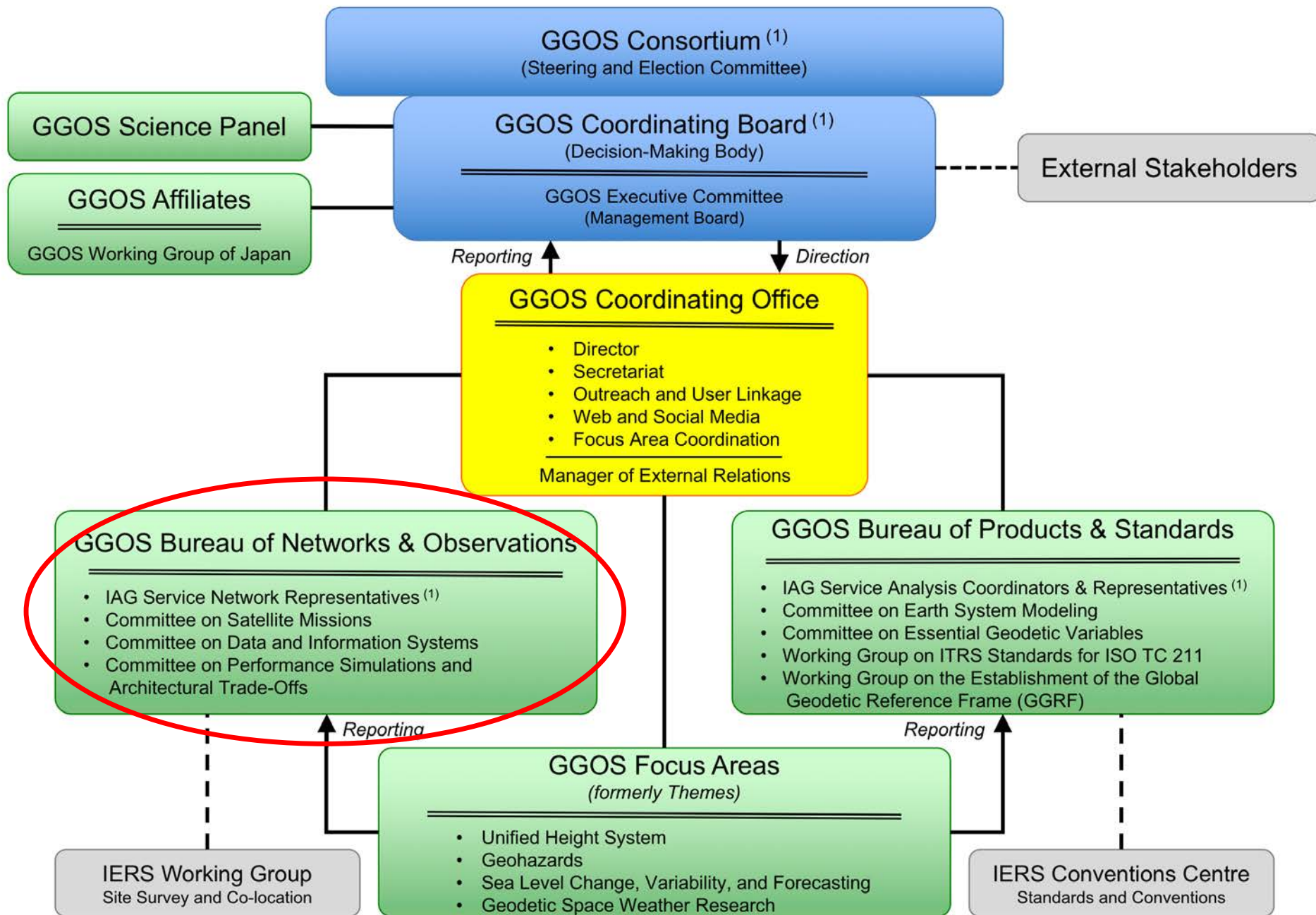


- GGOS has renewed its engagement with CEOS by appointing Craddock as the GGOS representative to their **Ad Hoc Team on the Sustainable Development Goals (AHT SDG)**, which highlights the potential role for Earth observations in supporting the global indicator framework of the United Nations Sustainable Development Goals

## International Council for Science (ICSU) World Data System (WDS)



- GGOS, a partner member of ICSU-WDS, may play an important part in encouraging data providers of the WDS to adopt or renew their **CoreTrustSeal**, the new WDS data certification process.
- ICSU is also developing **Essential Sustainability Variables**, which would be in alignment with GGOS's own recent initiative to define Essential Geodetic Variables.



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# Bureau of Networks and Observations

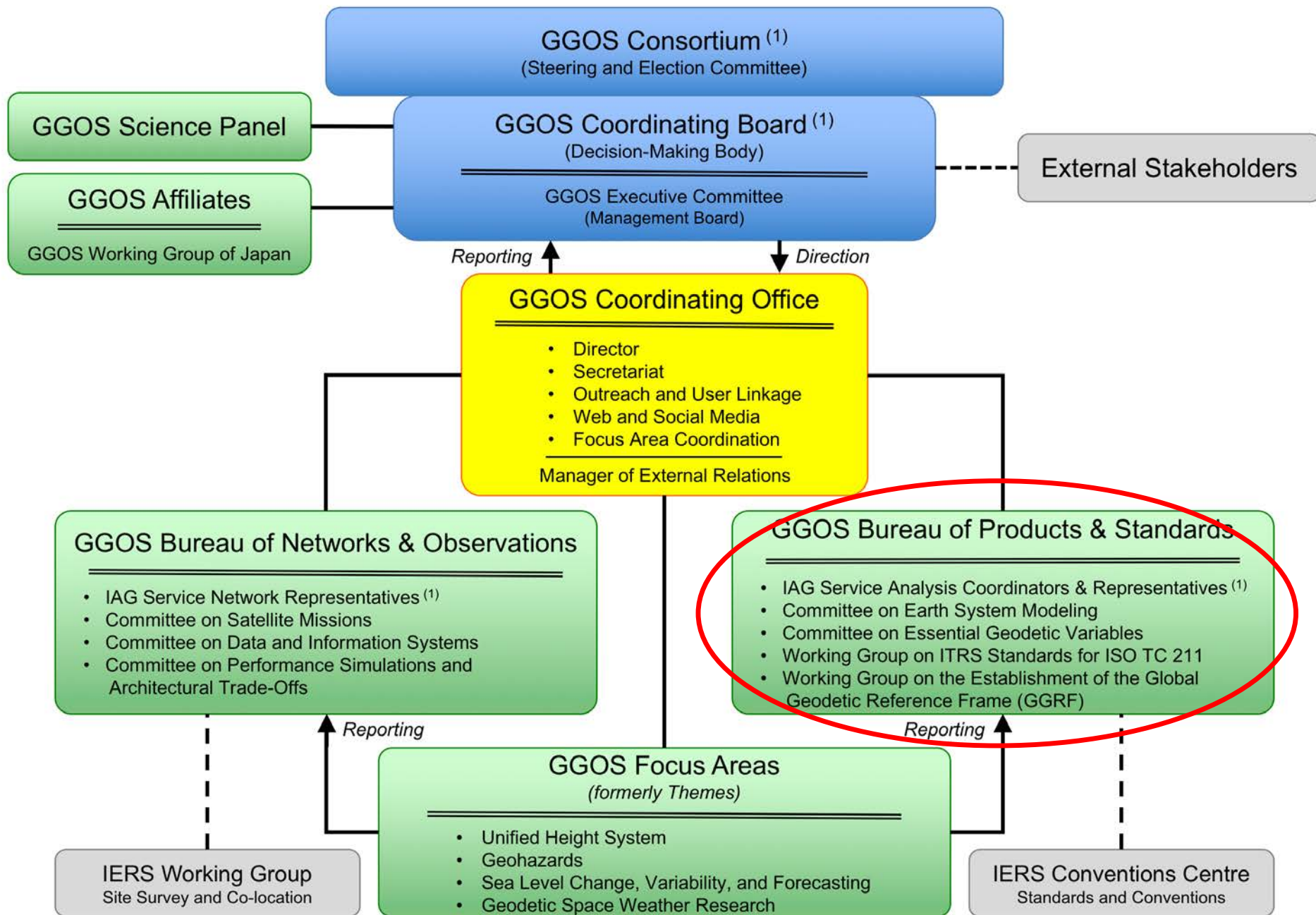
- Provide a forum for the Services and Standing Committees/Working Groups to share and discuss plans, progress, and issues, meetings in conjunction with annual AGU and EGU.
- Advocate for new and increased network participation, encouraging formation of new partnerships to develop new sites, monitored the status of the networks; meetings and communications held with representatives from Russia, Italy, Brazil, Japan, Spain, France, Korea, and Saudi Arabia to discuss implementation of new stations and upgrade of legacy stations.
- Continue the Bureau's "Call for Participation in the Global Geodetic Core Network: Foundation for Monitoring the Earth System"; 19 submissions have been received covering 114 sites that include legacy sites, new technology co-location and core sites, sites under development, and sites offered for future participation; a number of new sites plan to join once they are operational.
- See: <http://www.ggos.org/Components/BNO/>



# Bureau Activities

- Maintain and update the “Site Requirements for GGOS Core Sites” document (with the IAG Services); the next major step will be to include the requirements for the gravity field once it is fully documented by the IGFS and the IGRF working group; Work with the IGFS in the definition of its requirements.
- Advocate for the GGOS integrated global geodetic ground-based infrastructure through talks and posters at AGU, EGU, AOGS, APSG (China), JpGU-AGU, IAG, etc. and meetings and special presentations at GSI (Japan), IMPE (Brazil), IAP (Russia) etc.; support efforts to integrate relevant parameters from other ground networks (gravity field, tide gauges, etc.) into the GGOS network to support GGOS requirements.
- Work with the BP&S and the IGFS to help define the gravity field and unified height systems measurement requirements and encourage deployment of the field measurement systems.





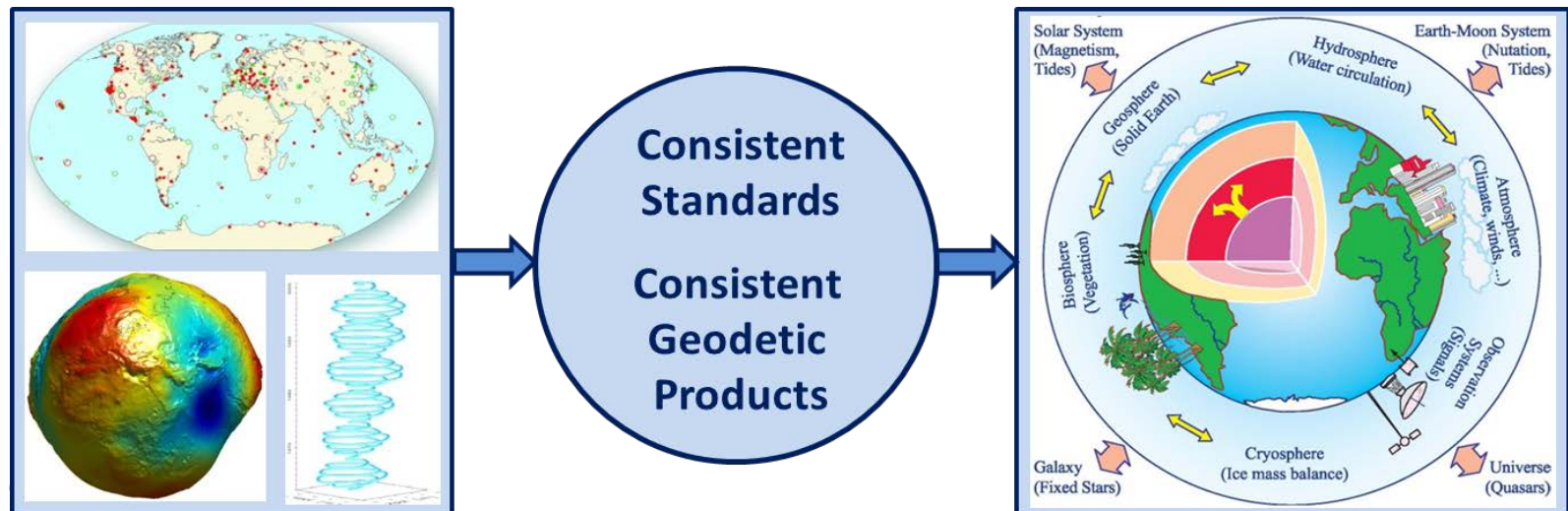
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# GOS Bureau of Products and Standards (BPS)

The BPS supports GGOS in its key goals to obtain consistent products describing the geometry, rotation and gravity field of the Earth.

## Mission and objectives

- to serve as contact and coordinating point for the homogenization of IAG/GGOS standards and products;
- to keep track of the adopted geodetic standards and conventions across all IAG components, and initiate steps to close gaps and deficiencies;
- to focus on the integration of geometric and gravimetric parameters and to develop new products, needed for Earth sciences and society.



# BPS Inventory

The BPS has compiled an inventory on standards and conventions used for the generation of IAG products:

- Review of numerical standards;
- Focus on IAG products: CRS/CRF, TRS/TRF, EOP, GNSS satellite orbits, gravity and geoid, heights;
- Assessment of the present status, identification of gaps, recommendations.

BPS inventory is published in the **IAG Geodesist's Handbook 2016**:  
*Angermann D., Gruber T., Gerstl M., Heinkelmann R., Hugentobler U., Sánchez L., Steigenberger P.* **GGOS Bureau of Products and Standards: Inventory of standards and conventions used for the generation of IAG products**. In: Drewes H., Kuglitsch F., Adám J. (Eds.) The Geodesist's Handbook 2016. Journal of Geodesy 90(10), 1095-1156, [10.1007/s00190-016-0948-z](https://doi.org/10.1007/s00190-016-0948-z), 2016

## Preface

Scope of the document

Acknowledgements

## 1 Introduction

1.1 GGOS: Mission, goals and structure

1.2 Standards and conventions

## 2 GGOS Bureau of Products and Standards

2.1 Mission and objectives

2.2 Tasks

2.3 Staff and representatives

## 3 Evaluation of numerical standards

3.1 Defining parameters

3.2 Solid Earth tide systems

3.3 Geopotential value  $W_0$

3.4 Open problems and recommendations

## 4 Product-based review

4.1 Celestial reference systems and frames

4.2 Terrestrial reference systems and frames

4.3 Earth Orientation Parameters (EOP)

4.4 GNSS satellite orbits

4.5 Gravity and geoid

4.6 Height systems and their realizations

## 5 Summary

Glossary

Bibliography

# Essential Geodetic Variables

- Observed variables
  - Crucial to characterizing geodetic properties of Earth
  - Key to sustainable geodetic observations
    - Positions of reference objects (ground stations, radio sources), EOPs
    - Gravity measurements (ground-based, space-based)
- Assign requirements to each EGV
  - Accuracy, spatial and temporal resolution, latency, stability, ...
- Derive requirements
  - On EGV-dependent products (TRF, CRF, ...)
  - On infrastructure (observing systems)
- Can be used to update GGOS2020 book
  - Bottoms-up approach to deriving requirements
    - Complements top-down approach used in GGOS2020 book (user needs)
- Establish Committee within GGOS BPS
  - To create list of EGVs, assign requirements to them, etc.
  - Committee will include representatives of
    - IAG Services, Commissions, Intercommission Committees, GGOS Focus Areas







# Focus Area 1

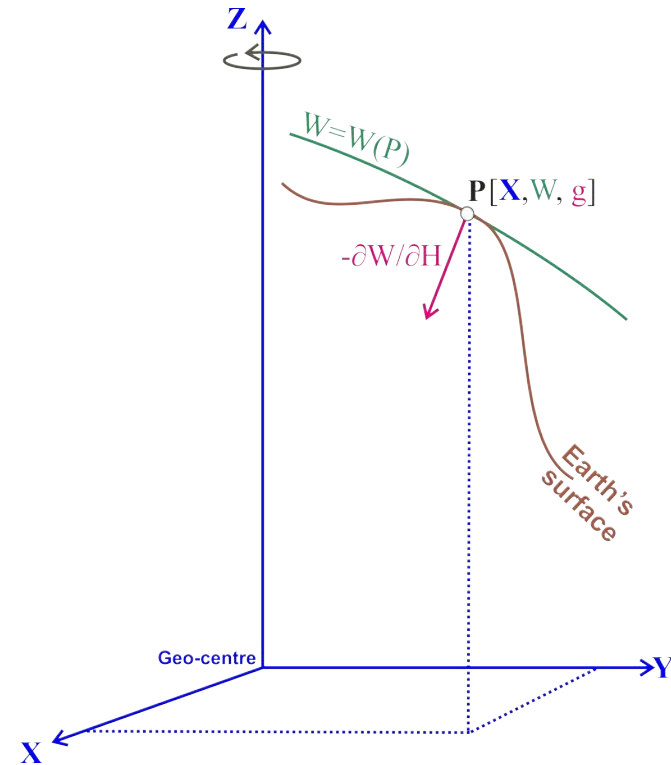
## Unified Height System

# Objective

A main objective of the [International Association of Geodesy](#) (IAG) and its [Global Geodetic Observing System](#) (GGOS) is the implementation of an integrated [Global Geodetic Reference Frame](#) (GGRF) that supports the consistent determination and monitoring of the Earth's geometry, rotation and gravity field with high accuracy worldwide.

The GGRF includes:

- Geocentric Cartesian coordinates  $\mathbf{X}$ ,  $\dot{\mathbf{X}}$
- Gravity vector  $\mathbf{g}$ ,  $\dot{\mathbf{g}}$
- Potential of the Earth's gravity field  $W$ ,  $\dot{W}$
- Physical height  $H$ ,  $\dot{H}$



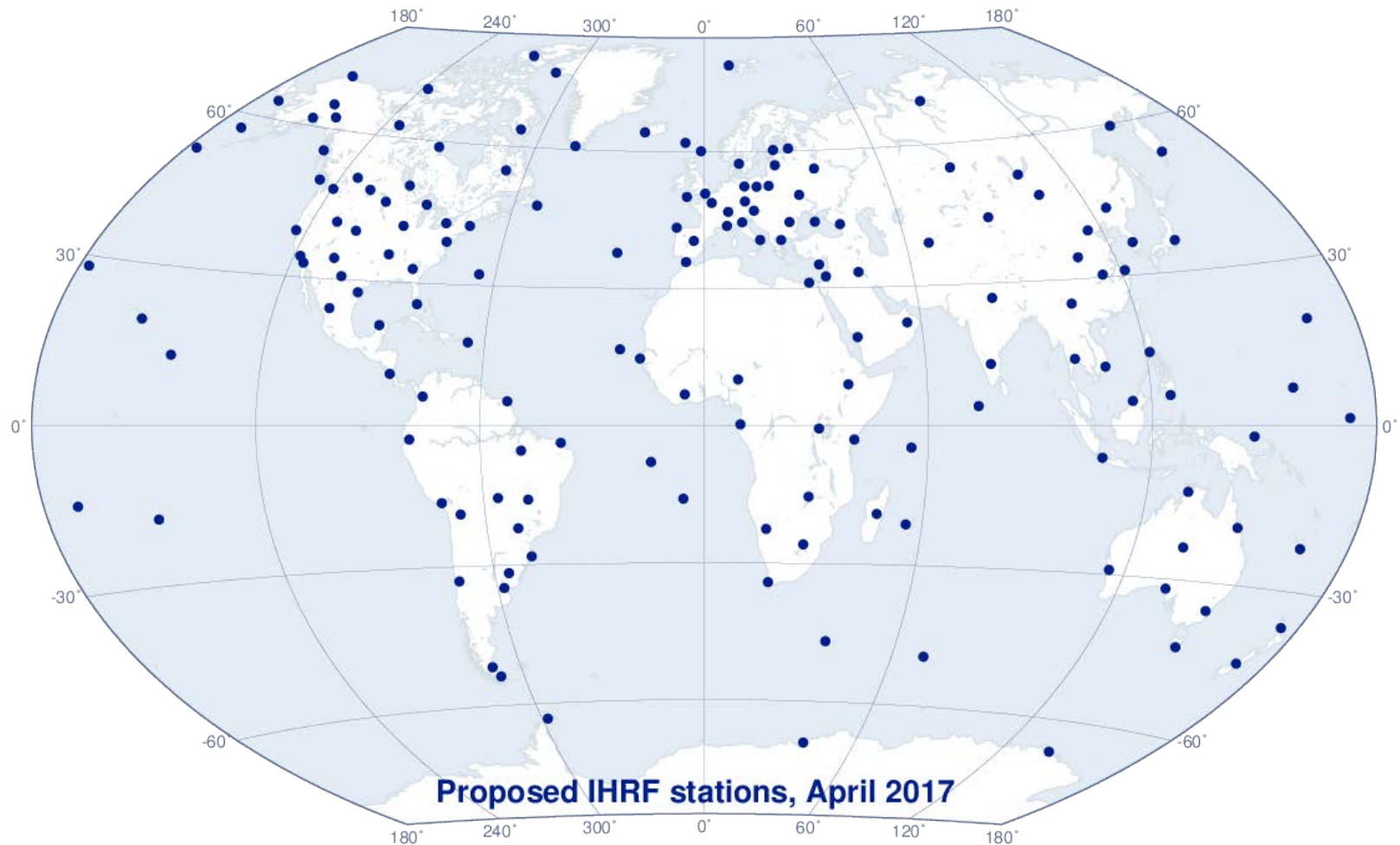
The GGOS Focus Area [Unified Height System](#) concentrates on the determination of a unified reference system for gravity, potential, and physical heights.

# Present activities

Implementation of the [International Height Reference System \(IHR\)](#) and its realization [IHRF \(International Height Reference Frame\)](#) introduced by the IAG Resolution No. 1, Prague, July 2015. This implies:

- Identification of [standards, conventions and procedures](#) required to ensure consistency between the definition (IHR) and the realization (IHRF): fundamental parameters, datum realization, time-depend variations, etc.
- Characteristics of the [reference network](#), station distribution, specifications for procedures and computations, selection of data, etc.
- Relationship between the IHR and the existing height systems: [vertical datum unification strategies](#).
- Collocation of the [IHRF with other geodetic reference frames like the GGOS core network](#), the ITRF, the new Global Absolute Gravity Reference System (see IAG Resolution 2, Prague 2015).
- Contributions [of the IHRF to the GGRF](#) (UN GGRF resolution 2015).

Recent achievements: First proposal for the IHRF reference network (Apr. 2017) and computation of potential values (Aug. 2017)



# Focus Area 2

## Geohazards

# The Vision: GGOS2020

The ***Global Geodetic Observing System (2009)*** set a path to develop and apply geodetic science, technology, and infrastructure to mitigate our vulnerability to natural hazards.

## Example: Tsunami Warning

The GGOS Geohazards Initiative **GNSS Augmentation for Tsunami Early Warning (GATEW)** builds upon the **IGS Real Time Service (GPS-RT)** and **IGS Multi-GNSS Experiment (M-GEX)**.

The **GATEW** Working Group will be a catalyst and motivating force to define requirements, identify resources, and encourage international cooperation.





***On April 1, 2016, the GGOS released the GATEW Call for Participation (CfP) in support of the IUGG- 2015***  
***(<https://www.dropbox.com/sh/fg20mtydg136vx6/AABNr2kSnMo429nCxEHhBDfoa?dl=0>).***

***The GATEW CfP called upon the community of agencies and institutions to join the GATEW working group to support and promote GNSS Augmentation to Tsunami Early Warning system as recommended by IUGG 2015 Resolution 4. (<http://www.iugg.org/resolutions/IUGGResolutions2015.pdf>).***

***The GATEW Working group now numbers 17 member agencies and institutions from 11 countries. The GATEW working group held its first meeting GTEWS 2017 in Sendai, Japan on July 25-27, 2017.***



## GGOS Working Group on GNSS Augmentation for Tsunami Warning

(As of January 13, 2018)

Country	Organization	Resources	Contact	Email
Australia	GeoScience Australia	Large National Real Time GNSS Network	John Dawson	John.Dawson@ga.gov.au
Chile	U.Chile, Department of Geophysics, CSN	Large National Real time Geodetic and Seismic Network	Sergio Barrientos, Sebastián Riquelme, Juan Baez	sbarrien@dgf.uchile.cl, sebastian@dgf.uchile.cl, jcbaez@csn.uchile.cl
China	GNSS Research Center, Wuhan University	First Real Time Asian Analysis Center	Jianghui Geng	jgeng@whu.edu.cn
China	Shanghai Observatory	Eminent geodetic research organization with strong experience in geodetic infrastructure, analysis and applications.	Shuanggen Jin	sgjin@shao.ac.cn
Colombia	Geological Survey Colombia	Large Real Time GNSS Network, Regional Data Sharing with Brazil, Peru, Panama, Venezuela, COCONet Data Center	Hector Mora	hmora@sgc.gov.co
France	Institut de Physique du Globe de Paris	Strong research in tsunami coupled ionospheric waves and tracking	Giovanni Occhipinti	ninto.a.paris@gmail.com
Germany	GeoForschung Zentrum, Department Geoservices	Strong research and development of GNSS Early Warning including Indonesia and Oman projects	Harald Shuh, Jörn Lauterjung	schuh@gfz-potsdam.de, lau@gfz-potsdam.de
Italy	University of Rome Geodesy and Geomatics	Initiating research in GNSS Tsunami Warning	Mattia Crespi, Augusto Mazzoni	<a href="mailto:mattia.crespi@uniroma1.it">mattia.crespi@uniroma1.it</a> , <a href="mailto:augusto.mazzoni@uniroma1.it">augusto.mazzoni@uniroma1.it</a>
Mexico	Instituto de Geofísica, UNAM	Large National GNSS network and analysis system, COCONet Data Center	Enrique Cabral	ecabral@geofisica.unam.mx
New Zealand	GNS Science	Large National Network	Elisabetta D'Anastasion	E.DAnastasio@gns.cri.nz
New Zealand	Land Information New Zealand	Large National Network	Dion Hansen	DHansen@linz.govt.nz
Sri Lanka	Survey Department of Sri Lanka	Strong interest in developing Tsunami Early Warning	P. Sangakkara, Mr A. Dissanayeke	<a href="mailto:dsggeode7c@survey.gov.lk">dsggeode7c@survey.gov.lk</a> , <a href="mailto:addsge@survey.gov.lk">addsge@survey.gov.lk</a>
USA	Georgia Tech	Significant focus on subduction zone activity and the generation of tsunamis	Andrew V. Newman	anewman@gatech.edu
USA	Jet Propulsion Laboratory	Real time expertise, Ionospheric mapping, global and operations, earthquake and tsunami warning	Attila Komjathy	attila.komjathy@jpl.nasa.gov
USA	UNAVCO	Global GNSS networks, real time data systems, Global GNSS support	Linda Rowan	rowan@unavco.org
USA	READI Working Group	NASA-NOAA working group developing GNSS Based Tsunami Warning	Yehuda Bock, Timothy Melbourne	ybock@ucsd.edu, tim@Geology.cwu.edu
USA	NASA	NASA Solid Earth Science. Provides funding from GNSS Tsunami Warning development. Cooperating with NOAA in this effort.	Gerald Bawden	gerald.w.bawden@nasa.gov



## GNSS TSUNAMI EARLY WARNING SYSTEM WORKSHOP

July 25-27, 2017 • Westin Hotel, Sendai, Japan



### Organizing Committee:

**John Rundle (Chair)**  
[jbrundle@ucdavis.edu](mailto:jbrundle@ucdavis.edu)  
University of California, Davis

**Shunichi Koshimura**  
Tohoku University, Sendai, Japan

**Yusaku Ohta**  
Tohoku University, Sendai, Japan

**John LaBrecque**  
Global Geodetic Observing System

**Yuichi Ono**  
Tohoku University, Sendai, Japan

**Takako Izumi**  
Tohoku University, Sendai, Japan

**Lorraine Hwang**  
University of California, Davis

[geodynamics.org/cig/events](http://geodynamics.org/cig/events)

For general information, contact:  
[events@geodynamics.org](mailto:events@geodynamics.org)

### First Call for Participation

**Workshop Purpose:** The past decade has witnessed a terrible loss of life related to large earthquakes and resultant tsunamis in the Indo-Pacific region. New and experimental algorithms based on real-time GNSS data and science now exist to rapidly determine the likelihood that a tsunami will be generated from a large earthquake, to predict their extent, inundation, and run-up, and to track the tsunami as it propagates through the ocean basins. The goals of this workshop are to:

- Identify what GNSS resources (networks, processing centers, telecommunication, etc.) will be necessary to develop real-time GNSS early warning capabilities throughout the entire Pacific Rim region
- Assess data gaps in the current Pacific-wide networks, develop strategies on the best approaches to fill the gaps
- Review the state-of-the-art early warning approaches with an eye towards emergency response community.

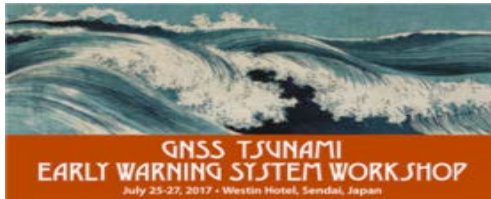
The Organizing Committee encourages your participation in a Global Navigation Satellite System Tsunami Early Warning System (GNSS-TEWS) workshop in Sendai. We encourage all interested participants to attend. Some level of travel support will be available to invited US-based speakers. The primary product of the workshop will be a report to identify strategies needed to understand the data needs for a Pacific-wide activity involving the Asia-Pacific Economic Cooperation (APEC) economies as well as other non-APEC economies.

Sponsored by the National Aeronautics and Space Administration  
Co-Sponsored by the

- Association of Pacific Rim Universities Multihazards Hub, Tohoku University, Sendai, Japan
- APRU-IRI/DeS Multi Hazards Program
- Global Geodetic Observing System

## GTEWS 2017: GNSS Tsunami Early Warning Workshop

### Sendai ,Japan July 25-27, 2017



#### REGISTRATIONS RECEIVED (61)

Arif Aditiya  
Miguel Angel Arestegui Espinal  
Andrey Babeyko  
Gerald Bawden  
Beldjilali Bilal  
Mattia Crespi  
Elizabeth D'Anastasio  
John Dawson  
Edilson Fernando  
James Foster  
Jeff Freymueller  
Eiichi Fukuyama  
Jianghui Geng  
Alexis Giguere  
Ken Gledhill  
Dara Goldberg  
Emma Hill  
Lorraine Hwang  
Daisuke Inazu  
Teruyuki Kato

Satoshi Kawamoto  
Attila Komjathy  
Shunichi Koshimura  
John LaBrecque  
Molly Luginbuhl  
Glen Mattioli  
Tim Melbourne  
Diego Melgar  
David Mencin  
Salazar Monroy  
Hector Mora-Paez  
Luis Moya  
Sebastian Munoz  
Andrew Newman  
Giovanni Occhipinti  
Keitaro Ohno  
Yusaku Ohta  
Jun Okada  
Makoto Okubo  
Shinichi Okuma

David Phillips  
Arliandy Pratama Arbad  
Queen Surajini Rajendran  
Linda Rowan  
Christine Ruhl  
John Rundle  
Joseph Sackey  
Victor Sardina  
Asuka Sato  
Giorgio Savastano  
Y. Tony Song  
Tim Stough  
Raza Tabassam  
Hiroaki Takahashi  
Inoue Takuya  
Kristy Tiampo  
Safi Ullah  
Christian Walls  
Steven Ward  
John Wilson  
Ankit Yadav



**Presentations and Discussions can be viewed here:**  
**<https://www.dropbox.com/s/s0c03xv34zfz7y4/2017%20GTEWS%20Program.pdf?dl=0>**

# GGOS Geohazards: Planned Actions and Milestones



- **The Geohazards Focus Area to work with IUGG GeoRisk Commission in development of a series of two inter-related two at the AGU and IUGG centennial meetings.**
  - **AGU 2018 Fall Meeting: December 10-14, 2018**
  - **IUGG 2019 General Assembly: Montreal, Canada July 8-17, 2019**
  - **Meetings will focus on the implementation of Disaster Science challenges, strategies, and opportunities with presentations and panel discussions by scientists, engineers, policy experts, and funding institutions.**
- **Seek continued membership expansion of and improved participation by members within the GATEW.**
- **Seek improved support of GATEW with other organizations by new GGOS outreach manager.**
- **Revise name and status of GATEW: Recommendation is standing committee and rename to GNSS Enhancement to Tsunami Early Warning (GETEW).**

# Focus Area 3

## Sea Level Change, Variability, and Forecasting



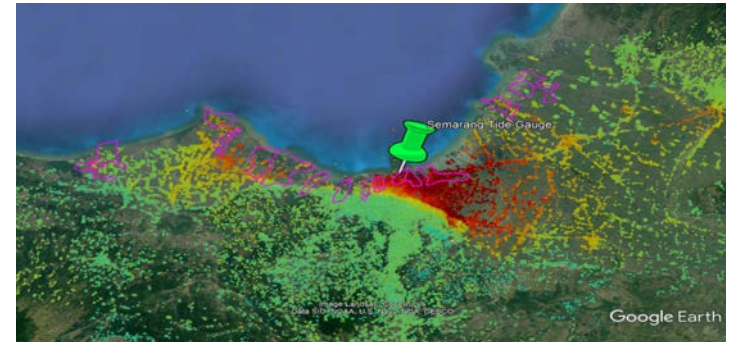
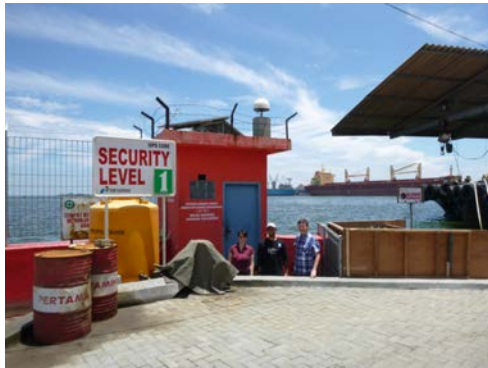
## Focus Area 3:

Understanding and Forecasting Sea-Level Rise and Variability

### Goals of FA3

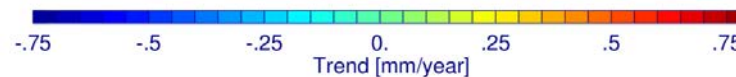
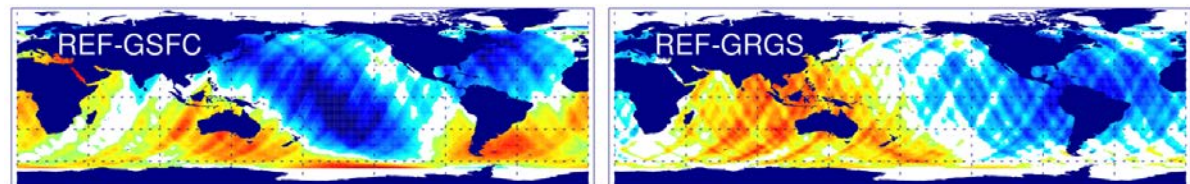
- Demonstration the value of the GGOS Infrastructure for Sea Level Monitoring and Forecasting
- Identification of the requirements for a proper understanding of global and regional/local sea-level rise and variability (relate to geodetic monitoring provided by the GGOS infrastructure).

Improving the Global Sea Level Monitoring Infrastructure (with IOC/GLOSS) and IGS/TIGA



Regional Impact Studies of Sea Level Rise, Subsidence and Social Adaption

Support Sea Level Community with, e.g., orbits, GNSS@TG information



REF-GSFC: 1.0 mm/yr  
REF-GRGS: 0.7 mm/yr

Focus Area 4  
Geodetic Space  
Weather Research

# Objectives of the Focus Area

- The **main objectives** of Focus Area 4 can be formulated as:
  1. Improvement in **positioning** and **navigation** by developing high-precision and high-resolution **models** of the **electron density** within the ionosphere,
  2. Improvement of **satellite orbit determination** by developing high-precision and high-resolution **thermospheric drag** models.

(Ionosphere and thermosphere are the „geodetic“ manifestations of space weather)
- **Additional Statements:**
  1. We understand these objectives with respect to both **fundamental research** and **practical applications**.
  2. Due to **fundamental research** the **running time** of the Focus Area has to be fixed to a **much longer** time span than the IAG period of **four years**.
  3. Furthermore, the **developed ionosphere** and **thermosphere models** can be interpreted as **GGOS products**.



## Joint Study Groups (JSG) related to Focus Area 4

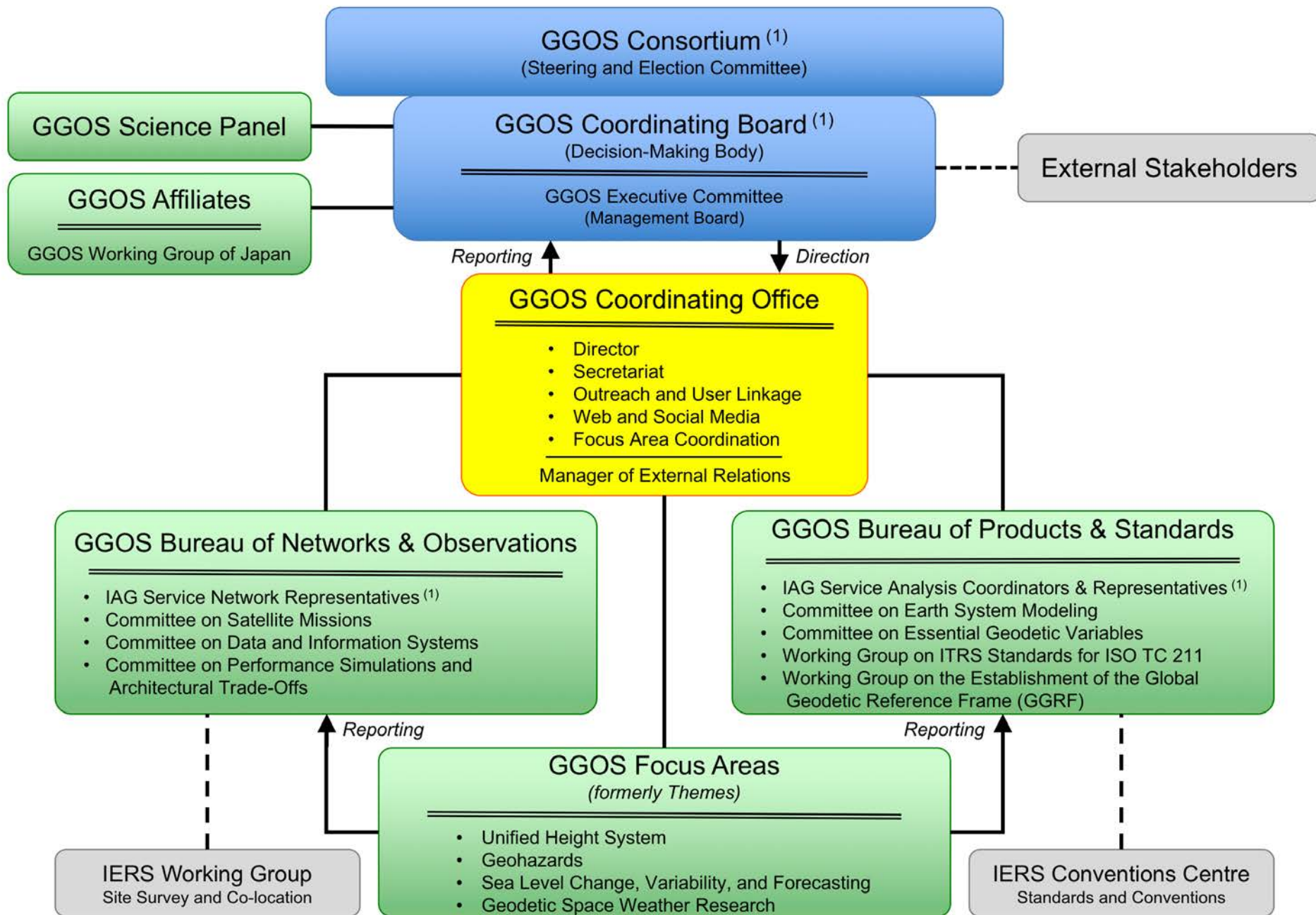
- For the **realization** of the objectives of Focus Area 4, at least **two new JSGs** have to be installed.
- Their **topics** could be formulated as:
  - **JSG 1: Electron density modelling** of the ionosphere including space weather effects and predictions approaches from the combination of space-geodetic measurement techniques.
  - **JSG 2: Improvement of thermosphere models** including physics-based realisations of **thermosphere-ionosphere coupling** processes, in particular for applications in the orbit determination of LEO satellites.
- Already existing IAG- and ICCT-Study Groups and -Working Groups of the **current IAG structure** will provide valuable input for the Focus Area.
- The work within the Focus Area will be carried out in close relation to the **International Association of Geomagnetism and Aeronomy (IAGA)**.

## Present Status and Progress:

1. Dr. Ehsan Forootan (Cardiff University, Cardiff, United Kingdom) became member of the GGOS Science Panel 2017-2018.
2. The three **new GGOS Joint Study Groups**
  - JSG 1: Electron density modelling
  - JSG 2: Improvement of thermosphere models
  - JSG 3: Coupling processes between thermosphere and ionosphereof the FA-GSWR have been installed.
3. Dr. Alberto Garcia-Rigo (UPC, Barcelona, Spain) became chair of JSG 1.
4. Dr. Andres Calabia Aibar (University of Colorado Boulder, USA) became chair of JSG 3.
5. The chair position of JSG 2 is still vacant – appropriate candidates have already been selected and approached.

## Next actions:

1. Selection of the members for the two Study Groups JSG 1 and JSG 3; setting up their corresponding Terms of Reference (ToR)
2. Presentation of a poster at the EGU 2018 in Vienna, GGOS Session G2.1, April 10, 2018
3. Presentation of a poster at the IX Hotine-Marussi Symposium in Rome, June 18-22, 2018, Title: 'GGOS Focus Area on Geodetic Space Weather Research – Basic Ideas'



<sup>(1)</sup> GGOS is built upon the foundation provided by the IAG Services, Commissions, and Inter-Commission Committees

# Global Geodetic Observing System

1. Requirements-setting organization for geodesy
  - GGOS 2020 book and its update
  - Essential Geodetic Variables
2. Forum for international collaboration
  - Improve integrated, global geodetic infrastructure
  - Improve geodetic products
    - Unified Analysis Workshops
3. Advocate for geodesy to broader community
  - Group on Earth Observations; Committee on Earth Obs. Satellites
    - Provide Earth observations (including geodetic) needed to make informed decisions
  - UN-GGIM Subcommittee on Geodesy
    - Emerging policy-making organization in geodesy
    - Emerging forum for international collaboration
4. Incubator for new initiatives in geodesy
  - Unified Height System
  - Sea Level Change, Variability, and Forecasting
  - Geohazards
  - Geodetic Space Weather Research



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Ruth E. Nollan (GGOS Vice-Chair) (Jet Propulsion Laboratory)  
Hans-Peter Plag (GGOS Vice-Chair) (University of Nevada)



